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## EUROPEAN PATENT APPLICATION

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### (54) Structure for shielding an electronic circuit from radio waves

(57) A structure (100) for shielding an electronic circuit (220) from radio waves is characterized by that the shield case (300) is formed therein with a cavity which is open in one side (310), that a first electrically conductive layer (330) is formed on an inner surface of the cavity; and that the printed wiring board (200) includes a main board (213) closing the cavity therewith as a cover, an electronic circuit (220) mounted on a lower surface of the main body (213), and a second electrically conductive layer (210) coextensive with the main body and making electrical contact with the first electrically conductive layer (330) when the printed wiring board is put onto the open side (310) of the shield case (300). The second electrically conductive layer cooperates with the first electrically conductive layer to form a shielded space in which an electronic circuit is to be mounted.

FIG.2B

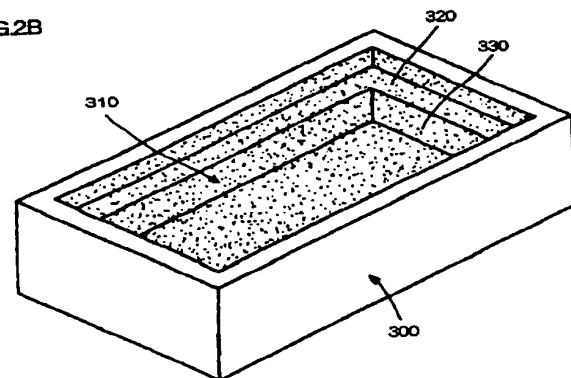
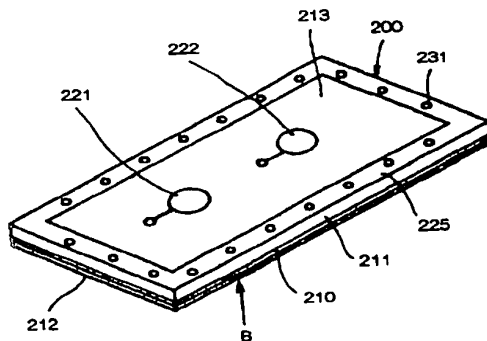


FIG.2A



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## Description

### BACKGROUND OF THE INVENTION

#### FIELD OF THE INVENTION

The invention relates to a structure for shielding an electronic circuit from radio waves, and more particularly to a structure for shielding a radio-frequency circuit equipped with an antenna.

#### DESCRIPTION OF THE PRIOR ART

A conventional structure for shielding a radio-frequency circuit is comprised of a shield case composed of metal for encasing a radio-frequency circuit therein to shield the circuit from radio-waves. Accordingly, since an antenna has to be arranged outside the shield case, the radio-frequency circuit is electrically connected to the antenna through a connector and a cable.

In order to solve this problem, Japanese Unexamined Utility Model Publication No. 64-40910 published on March 10, 1989 has suggested such a plastic shield case as illustrated in Figs. 1A and 1B. Fig. 1A is a perspective view of the suggested plastic shield case, and Fig. 1B is a cross-sectional view taken along the line IB-IB in Fig. 1A.

The plastic shield case is constituted of an upper half 2a and a lower half 2b. A radio-frequency circuit (not illustrated) is formed on an upper surface of a printed wiring board 1. The upper and lower halves 2a and 2b are assembled in such a manner that the printed wiring board 1 is sandwiched between the upper and lower halves 2a and 2b. Each of the upper and lower halves 2a and 2b are formed with two cavities, and inner surfaces of those two cavities are covered with an electrically conductive layer 3 composed of metal for radio-waves shielding. The electrically conductive layer 3 partially extend outside the upper half 2a to thereby form an antenna element 4.

In accordance with the suggested shield case, the radio-frequency circuit can be electrically connected to the antenna element 4 without a connector and a cable.

However, the above-mentioned plastic shield case has to have the two halves 2a and 2b for sandwiching the printed wiring board 1 therebetween. The reason is as follows. If the printed wiring board 1 is shielded only at an upper surface on which an electronic circuit is mounted, external radio-waves enter the electronic circuit and internal radio-waves leaks from the electronic circuit both through a lower surface of the printed wiring board. Thus, it is absolutely necessary to shield the printed wiring board at upper and lower surfaces thereof.

The use of the upper and lower halves 2a and 2b poses a problem that the shield structure is totally heavy, big in size, and high in fabrication cost.

In addition, in the above-mentioned plastic shield

case, the antenna element 4 is formed on the upper half 2a separately from the printed wiring board 1 on which a radio-frequency circuit is formed. Hence, when the printed wiring board 1 is shielded with the upper and lower halves 2a and 2b, it is necessary to electrically connect the radio-frequency circuit to the antenna element 4.

As a result, assembly of the plastic shield case would take much time and much labor. In addition, when the plastic shield case is disassembled to take out the printed wiring board 1 for inspection and is assembled again, laborious work has to be done, specifically, the radio-frequency circuit is disconnected from the antenna element 4 and connected again to the antenna element 4., in which case, the radio-frequency circuit may be imperfectly, electrically connected to the antenna element 4.

#### SUMMARY OF THE INVENTION

In view of the foregoing problems, it is an object of the present invention to provide a structure for shielding an electronic circuit, which can be formed in a smaller size, a smaller weight, and a lower cost, and which can be readily assembled.

In one aspect of the present invention, there is provided a structure for shielding an electronic circuit from radio waves, including a shield case and a printed wiring board, characterized by that the shield case is open in one side and is covered at an inner surface thereof with a first electrically conductive layer, and that the printed wiring board includes a second electrically conductive layer which cooperates with the first electrically conductive layer to form a shielded space in which an electronic circuit is to be mounted, when the printed wiring board is put onto the open side of the shield case.

There is further provided a structure for shielding an electronic circuit from radio waves, including a shield case and a printed wiring case, characterized by that the shield case is formed therein with a cavity which is open in one side of the shield case, that a first electrically conductive layer is formed on an inner surface of the cavity, and that the printed wiring board including (a) a main board closing the cavity therewith as a cover, (b) an electronic circuit mounted on a lower surface of the main body, and (c) a second electrically conductive layer coextensive with the main body and making electrical contact with the first electrically conductive layer when the printed wiring board is put onto the open side of the shield case, the second electrically conductive layer cooperating with the first electrically conductive layer to form a shielded space in which an electronic circuit is to be mounted.

In accordance with the above-mentioned shield structure, the shield case and the printed wiring board cooperate with each other to form a shielded space, in which an electronic circuit formed on a lower surface of the printed wiring board is put. In addition, since the first

electrically conductive layer makes electrical contact with the second electrically conductive layer to thereby form an electrically shielded space, the electronic circuit is also put in the thus formed electrically shielded space. Thus, since the printed wiring board forms a part of the shield structure, only one shield case is necessary for forming the shield structure unlike the conventional shield structure wherein two halves are required for forming a shield case. Hence, the shield case in accordance with the present invention can be formed in a smaller weight, a smaller volume, and a lower cost.

It is preferable that the shield case is formed at the open side thereof with a stepped portion on which the main board of the printed wiring board is to be put.

For instance, the first electrically conductive layer may be composed of an electrically conductive coating film which is composed of, for instance, a coating including metal powders therein. For instance, the shield case is made of plastics.

For instance, the second electrically conductive layer may be composed of a metal foil, or a metal film evaporated onto the main board of the printed wiring board.

In a preferred embodiment, the shield structure further includes an antenna formed on an upper surface of the main board of the printed wiring board in such a manner that the antenna is in electrical connection with the electronic circuit.

In accordance with this embodiment, since an antenna and an electronic circuit are formed on opposite surfaces of the main body, and the antenna is electrically connected to the electronic circuit, it is no longer necessary to carry out a step of electrically connecting an antenna to an electronic circuit, which ensures that an imperfect contact between an antenna and an electronic circuit does not occur.

When the shield structure further includes an antenna, it is preferable that the main board is formed with at least one through-hole extending between upper and lower surfaces thereof, and the antenna and the electronic circuit make electrical connection with each other through a wire extending in the through-hole.

The printed wiring board may further include a plurality of printed boards, in which case the main board and the second electrically conductive film are sandwiched between two of the printed boards. When the printed wiring board includes two printed boards, the main board is sandwiched between them. When the printed wiring board further includes a plurality of printed boards, it is preferable that the printed wiring board includes (a) an upper electrode layer formed at a marginal region of an upper surface of an uppermost printed board, (b) a lower electrode layer formed at a marginal region of a lower surface of a lowermost printed board, and (c) a third electrically conductive layer causing the upper and lower electrode layers and the second electrically conductive layer to make electrical connection with one another. In this case, it is preferable that the lower electrode layer makes contact with the first electrically conductive layer, so that the first and second electrically conductive layers make electrical contact with each other through the third electrically conductive layer.

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It is preferable that at least one through-hole is formed through the printed boards, the main board, and the second electrically conductive layer so that the through-hole reaches the upper and lower electrode layers, and further comprising a third electrically conductive layer formed on an inner surface of the through-hole.

It is preferable that the third electrically conductive layer is formed on a side surface of the printed wiring board between the upper and lower electrode layers.

In accordance with the above-mentioned shield structure, a shield for an electronic circuit is formed in only two parts: a shield case and a printed wiring board. Thus, it is possible to form a shield structure in a smaller size, a smaller weight, and a lower cost.

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

Fig. 1A is a perspective view of a conventional shield case.

Fig. 1B is a cross-sectional view taken along the line IB-IB in Fig. 1A.

Fig. 2A is a perspective view of a printed wiring board constituting a part of a shield structure in accordance with the first embodiment of the present invention.

Fig. 2B is a perspective view of a shield case constituting a part of a shield structure in accordance with the first embodiment of the present invention.

Fig. 3 is an exploded perspective view of the printed wiring board illustrated in Fig. 2A.

Fig. 4 is a perspective view of the printed wiring board at a lower surface thereof, as viewed from an arrow B shown in Fig. 2A.

Fig. 5 is a cross-sectional view of a shield structure in accordance with a preferred embodiment of the present invention.

Fig. 6 is a cross-sectional view of a printed wiring board, illustrating another structure of the second electrically conductive film.

#### **DESCRIPTION OF THE PREFERRED EMBODIMENTS**

With reference to Figs. 2A and 2B, a structure 100 for shielding an electronic circuit is comprised of a printed wiring board 200 illustrated in Fig. 2A and a shield case 300 illustrated in Fig. 2B.

As illustrated in Fig. 2B, the shield case 300 is open in an upper side thereof, and is made of plastic. The shield case 300 is formed at the open side 310 thereof with a stepped portion 320, onto which the printed wiring board 200 is fit to thereby close the open side 310 of the shield case 300.

The shield case 300 is formed at an entire inner surface thereof with a first electrically conductive layer 330 acting as a shielding material. For instance, the electrically conductive layer 330 may be composed of an electrically conductive coating film, which may be formed by spraying a paint containing metal powders therein onto an inner surface of the shield case 300.

As illustrated in Fig. 3, the printed wiring board 200 includes a main board 213 having a three-layered structure. Specifically, the main board 213 is comprised of a second electrically conductive layer 210 composed of metal foil, a first printed board 211 formed on the second electrically conductive layer 200, and a second printed board 212 formed below the second electrically conductive layer 200. The main board 213 is fit into the stepped portion 320 of the open side 310 of the shield case 300.

A radio-frequency circuit block 220 is formed on a lower surface of the second printed board 212 of the main board 213, as illustrated in Fig. 4. As mentioned later, the second electrically conductive layer or metal foil 210 shields the radio-frequency circuit block 220 from radio-waves.

As illustrated in Fig. 3, the first printed board 211 is formed on an upper surface thereof with two antennas 221 and 222. The antennas 221 and 222 are formed, for instance, by steps of forming a metal film on an upper surface of the first printed board 211 by evaporation or plating, for instance, and etching the thus formed metal film into a desired pattern.

As illustrated in Figs. 3 and 4, there are formed through-holes 230 in the vicinity of the antennas 221 and 222 throughout the first printed board 211, the metal foil 210, and the second printed board 212. The antennas 221 and 222 formed on an upper surface of the first printed board 211 and the radio-frequency circuit block 220 formed on a lower surface of the second printed board 212 are electrically connected with each other through electrically conductive wires (not illustrated) extending between the antennas 221, 222 and the radio-frequency circuit block 220 through the through-holes 230.

As illustrated in Fig. 4, a lower GND electrode layer 224 is formed in the form of a strip at a marginal region on a lower surface of the second printed board 212. Similarly, as illustrated in Fig. 3, an upper GND electrode layer 225 is formed in the form of a strip at a marginal region on an upper surface of the first printed board 211. These lower and upper GND electrode layers 224 and 225 may be formed by plating, for instance.

As best illustrated in Fig. 3, there are formed a plurality of through-holes 231 throughout the first printed board 211, the second electrically conductive layer 210, and the second printed board 212 so that the through-holes 231 reach the lower and upper GND electrode layers 224 and 225.

As illustrated in Fig. 5, a third electrically conductive layer 227 is formed on an inner surface of each of the

through-holes 231, for instance, by plating. The third electrically conductive layer 227 ensures that the upper and lower GND electrode layers 225, 224 and the second electrically conductive layer or metal foil 210 to make electrical connection with one another.

The shield structure 100 in accordance with the present embodiment is completed by closing the open side 310 of the shield case 300 with the printed wiring board 200. Fig. 5 is a cross-sectional view of the shield structure where the printed wiring board 200 is put onto the stepped portion 320 of the shield case 300. Hereinbelow is explained functions of the shield structure 100 in accordance with the present embodiment, with reference to Fig. 5.

The printed wiring board 200 is put onto the stepped portion 320 of the shield case 300 in such a manner that the radio-frequency circuit block 220 is enclosed in the shield case 300. Thus, the radio-frequency circuit block 220 is hermetically shielded in a closed cavity defined by the printed wiring board 200 and the shield case 300.

When the printed wiring board 200 is put onto the stepped portion 320 of the shield case 300, the first electrically conductive layer 330 formed on an inner surface of the shield case 300 makes electrical contact with the lower GND electrode layer 224 at the stepped portion 320. Hence, the second electrically conductive layer 210 makes electrical contact with the first electrically conductive layer 330 through both the third electrically conductive layer 227 and the lower GND electrode layer 224.

Accordingly, the radio-frequency circuit block 220 formed on a lower surface of the second printed board 212 is enclosed within a shielded space defined by the second electrically conductive layer 210, the third electrically conductive layer 227, the lower and upper GND electrode layers 224 and 225, and the first electrically conductive layer 330, all of which are electrically connected to one another. As a result, the radio-frequency circuit block 220 is shielded from external radio-waves, and leaks no radio-waves to outside.

Since the antennas 221 and 222 are formed on an upper surface of the first printed board 211, the antennas 221 and 222 become integral with the shield structure 100 by covering the shield case 300 with the printed wiring board 200. The antennas 221 and 222 are shielded from the radio-frequency circuit block 220 by means of the first electrically conductive layer 210 located therebetween.

As mentioned so far, the present embodiment provides the shield structure 100 defined by the plastic shield case 300 and the printed wiring board 200 for shielding the radio-frequency circuit block 220. The shield structure 100 has a height almost equal to a height of the shield case 300. Hence, since the shield structure 100 can be formed of a single shield case unlike the conventional shield case comprised of two shield cases with a printed wiring board sandwiched

therebetween, the shield structure 100 can be formed in a smaller height, a smaller weight, and a smaller fabrication cost.

In addition, since the antennas 221 and 222 are formed integrally with the printed wiring board 200, it is no longer necessary to use a connector and a cable for connecting the radio-frequency circuit block 220 and the antennas 221 and 222. This also contributes to that the shield structure 100 is formed in a smaller size, a smaller weight, and a smaller cost. Since the antennas 221, 222 and the radio-frequency circuit block 220 are electrically connected to each other without using movable parts unlike the conventional shield structure, it is possible to avoid imperfect contact therebetween.

In the above-mentioned embodiment, the third electrically conductive layer 227 is formed on an inner surface of the through-holes 231. However, it should be noted that the third electrically conductive layer 227 might be designed to have other forms. For instance, as illustrated in Fig. 6, the third electrically conductive layer 227 may be formed as a layer 226 vertically extending on a side surface of the printed wiring board 213 so that the third electrically conductive layer 227 bridges between the lower and upper GND electrode layers 224 and 225.

As an alternative, the third electrically conductive layer 226 may be formed integrally with the lower and upper GND electrode layers 224 and 225, in which case, the third electrically conductive layer 226 is almost U-shaped.

In the above-mentioned embodiment, the second electrically conductive layer 210 is composed of metal foil. However, the second electrically conductive layer 210 may be composed of a thin metal film formed, for instance, by evaporation onto either an upper surface of the second printed wiring board 211 or a lower surface of the first printed wiring board 211. The first electrically conductive layer 330 may be formed by evaporation or plating in place of using an electrically conductive coating film.

Though the main board 213 is formed as having a three-layered structure in the above-mentioned embodiment, the main board 213 may be designed to have a four- or more layered structure.

It should be noted that a circuit to be shielded by the shield structure 100 in accordance with the above-mentioned embodiment is not to be limited to the radio-frequency circuit 220.

#### Claims

1. A structure (100) for shielding an electronic circuit (220) from radio waves, comprising a shield case (300) and a printed wiring board (200), characterized by that

the shield case (300) is open in one side (310) and is covered at an inner surface thereof with

a first electrically conductive layer (330), and that

the printed wiring board (200) includes a second electrically conductive layer (210) which cooperates with the first electrically conductive layer (330) to form a shielded space in which an electronic circuit (220) is to be mounted, when the printed wiring board (200) is put onto the open side (310) of the shield case (300).

2. A structure (100) for shielding an electronic circuit (220) from radio waves, comprising a shield case (300) and a printed wiring board (200), characterized by

that the shield case (300) is formed therein with a cavity which is open in one side (310) of the shield case (300),

that a first electrically conductive layer (330) is formed on an inner surface of the cavity; and that the printed wiring board (200) includes:

(a) a main board (213) closing the cavity therewith as a cover;

(b) an electronic circuit (220) mounted on a lower surface of the main body (213); and

(c) a second electrically conductive layer (210) coextensive with the main body (213) and making electrical contact with the first electrically conductive layer (330) when the printed wiring board (200) is put onto the open side (310) of the shield case (300), the second electrically conductive layer (210) cooperating with the first electrically conductive layer (330) to form a shielded space in which an electronic circuit (220) is to be mounted.

3. The structure as set forth in claim 2, wherein the shield case (300) is formed at said open side (310) thereof with a stepped portion (320) on which the main board (213) of the printed wiring board (200) is to be put.

4. The structure as set forth in claim 2 or 3, wherein the first electrically conductive layer (330) is composed of an electrically conductive coating film.

5. The structure as set forth in claim 4, wherein the electrically conductive coating film is composed of a coating including metal powders therein.

6. The structure as set forth in claim 2 or 3, wherein the second electrically conductive layer (210) is composed of a metal foil.

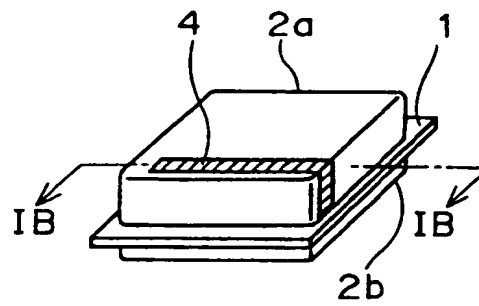
7. The structure as set forth in claim 2 or 3, wherein the second electrically conductive layer (210) is

composed of a metal film evaporated onto the main board (213) of the printed wiring board (200).

third electrically conductive layer (227) is formed on a side surface of the printed wiring board (200) between the upper and lower electrode layers (225, 224).

8. The structure as set forth in claim 2 or 3, further comprising an antenna (221, 222) formed on an upper surface of the main board (213) of the printed wiring board (200) in such a manner that the antenna (221, 222) is in electrical connection with the electronic circuit (220). 5
9. The structure as set forth in claim 8, wherein the main board (213) is formed with at least one through-hole (230) extending between upper and lower surfaces thereof, the antenna (221, 222) and the electronic circuit (220) making electrical connection with each other through a wire extending in the through-hole (230). 10 15
10. The structure as set forth in claim 2 or 3, wherein the printed wiring board (200) further includes a plurality of printed boards (211, 212), the main board (213) and the second electrically conductive film (210) being sandwiched between two of the printed boards (211, 212). 20 25
11. The structure as set forth in claim 10, wherein the printed wiring board (200) includes:
  - (a) an upper electrode layer (225) formed at a marginal region of an upper surface of an uppermost printed board (211); 30
  - (b) a lower electrode layer (224) formed at a marginal region of a lower surface of a lowermost printed board (212); and
  - (c) a third electrically conductive layer (227) causing the upper and lower electrode layers (225, 224) and the second electrically conductive layer (210) to make electrical connection with one another. 35 40
12. The structure as set forth in claim 11, wherein the lower electrode layer (224) makes contact with the first electrically conductive layer (330), so that the first and second electrically conductive layers (330, 210) make electrical contact with each other through the third electrically conductive layer (227). 45
13. The structure as set forth in claim 11, wherein at least one through-hole (231) is formed through the printed boards (211, 212), the main board (213), and the second electrically conductive layer (210) so that the through-hole (231) reaches the upper and lower electrode layers (225, 224), and further comprising a third electrically conductive layer (227) formed on an inner surface of the through-hole (231). 50 55
14. The structure as set forth in claim 11, wherein the

**FIG. 1 A**  
PRIOR ART



**FIG. 1 B**  
PRIOR ART

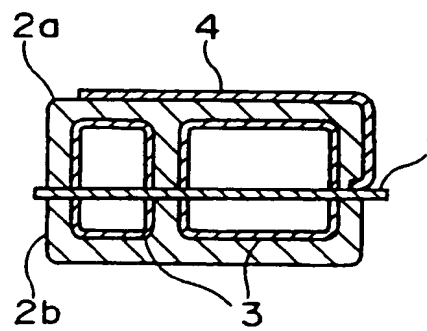


FIG.2A

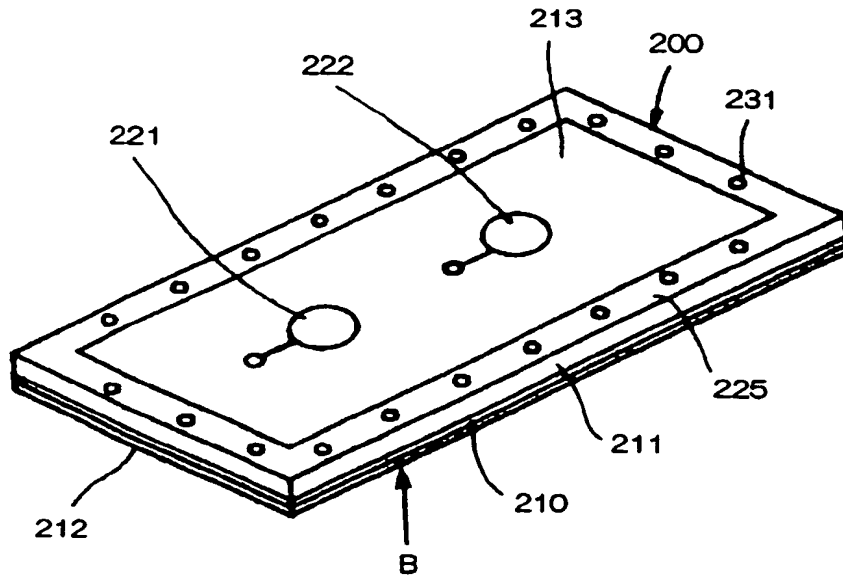


FIG.2B

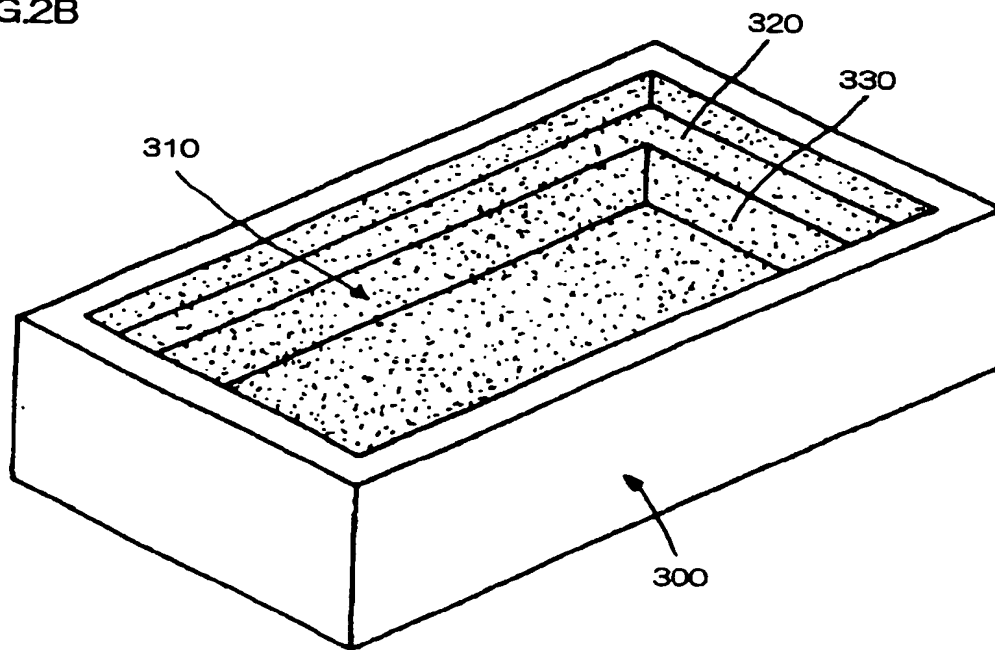




FIG.3

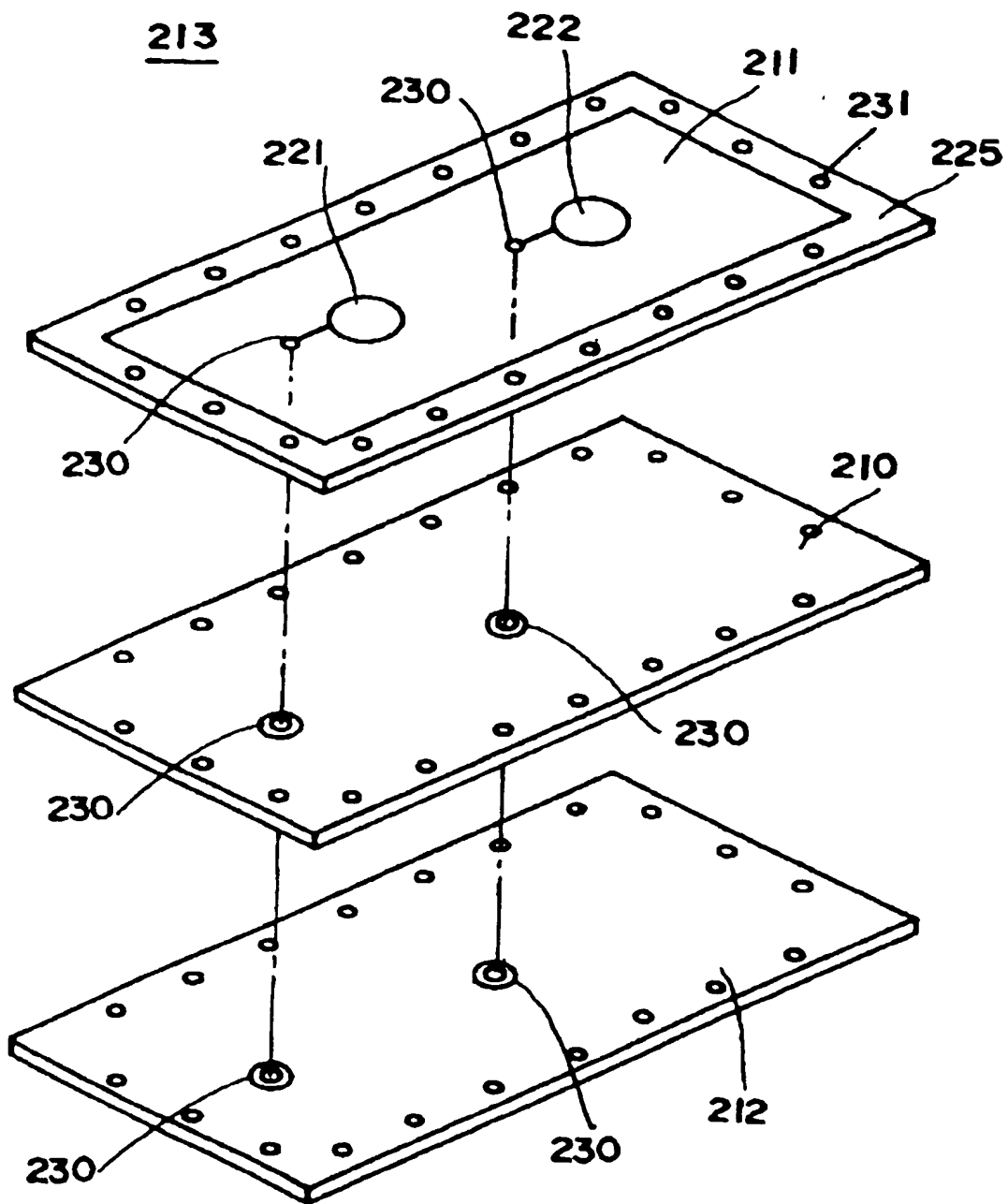


FIG.4

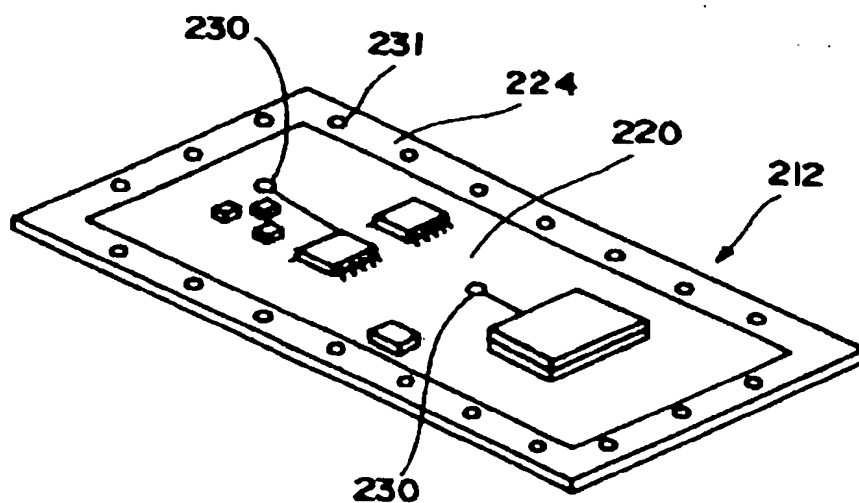


FIG. 5

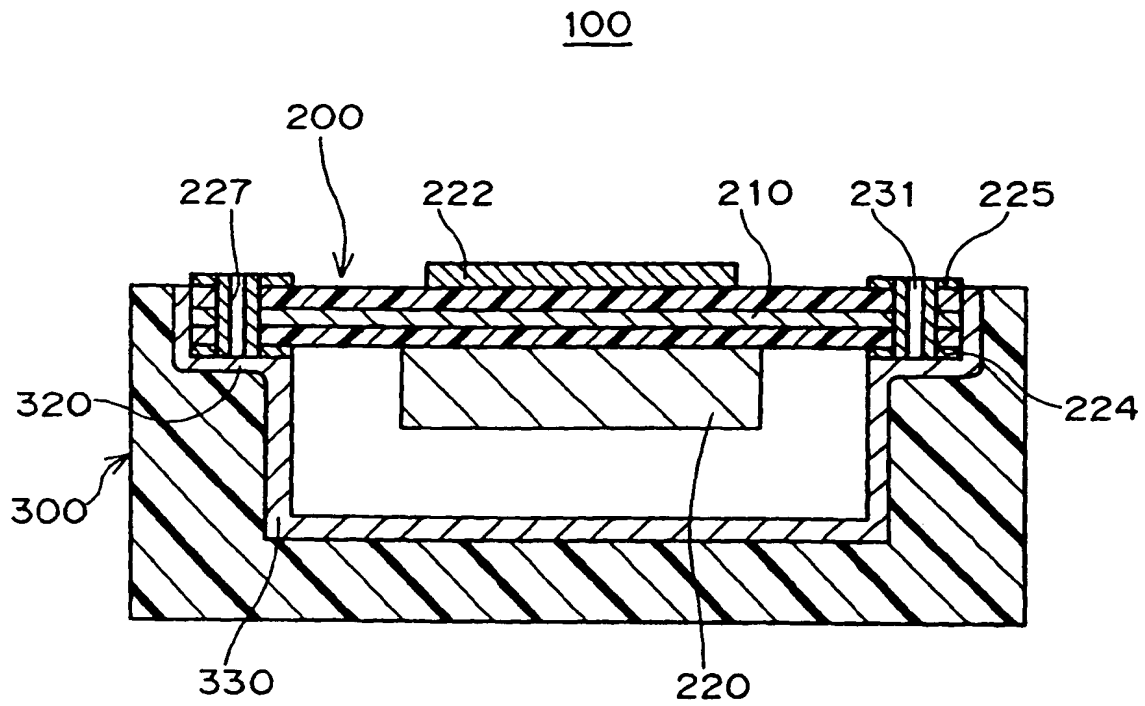
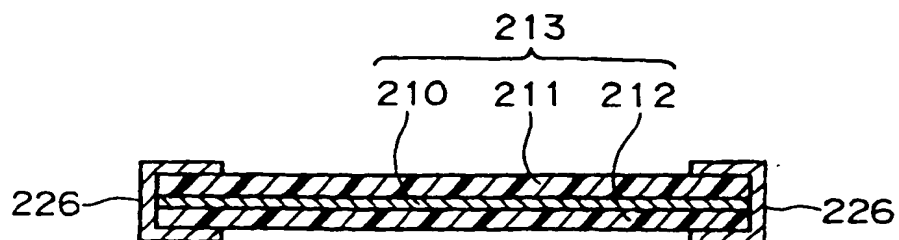
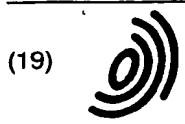


FIG. 6





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FIG.2B

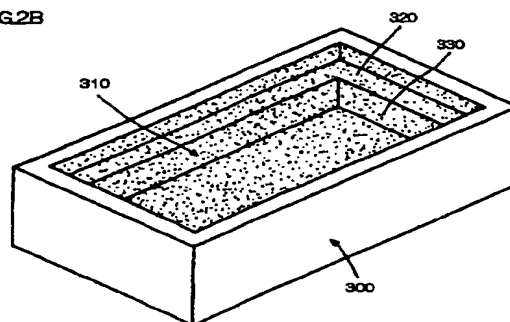
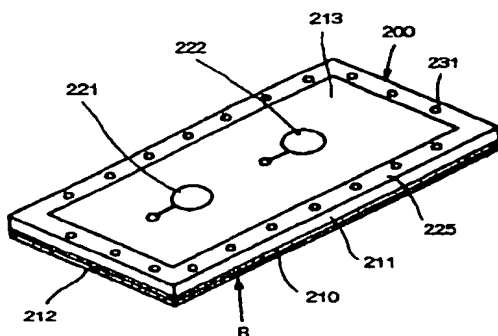


FIG.2A



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European Patent  
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## EUROPEAN SEARCH REPORT

Application Number  
EP 98 11 1758

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	DE 295 15 035 U (SIEGFRIED SCHAAL METALLVEREDEL) 11 January 1996	1,2,4,7	H05K9/00
A	* page 4, paragraph 1 - paragraph 2; figure 2 *	3,5,8-14	
A	US 5 566 055 A (SALVI JR JOSEPH A) 15 October 1996 * column 2, line 41 - line 60 * * column 4, line 1 - line 64; figures *	1-14	
A	US 5 418 685 A (JESSBERGER THOMAS ET AL) 23 May 1995 * column 3, line 57 - line 66; figure 4 *	1-14	
A	US 5 412 340 A (TANIKOSHI SADA0) 2 May 1995 * column 6, line 37 - line 55; figure 4A *	1-14	
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			H05K
Place of search	Date of completion of the search	Examiner	
THE HAGUE	17 June 1999	Rubenowitz, A	
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	
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EPO FORM 1503 03 82 (P4/C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT  
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EP 98 11 1758

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.  
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17-06-1999

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82